



Baking the Perfect Cookie

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Cookie Consumption

- Cookies are a small, sweet, and typically round baked good with a crispy or chewy texture.
- The origin of the cookie can be traced back to Persia, in the 7th century AD.
- There are many types of cookies including; oatmeal cookies, peanut butter cookies, shortbread, biscotti, and the **famous chocolate chip cookie**.
- Cookies are widely consumed around the world and have a growing market value.
- Global market value is expected to hit USD 44 billion by 2025.

Main Ingredients

- Cookies typically contain flour, sugar and some type of fat or oil.
- Other components that can be included are raisins, oats, almonds, chocolate chips.
- Correct measurements of each ingredient that goes into a cookie is important.
- Changes in quantities measured can lead to drastic changes in the outcome of cookie.
- The extent to which the dough piece spreads during baking, i.e cookie diameter, is a major parameter of interest for bakers.
- Cookie diameter will vary depending on the amounts of ingredients and baking methods



Research question

Question: How do factors such as the amount of *flour*, *butter*, and *baking time* affect the *diameter* of finished cookies?

Hypothesis: We hypothesize that the diameter of the cookie is mostly controlled by the amount of flour and butter, but is also modified by other variables including baking time

Methods

Cookies were baked at 350° F for 9 or 12 minutes on a nonstick cookie sheet.

Original Recipe:

- 1 egg yolk
- 25 grams sugar
- 50 grams brown sugar
- 60 grams chocolate chips
- 0.5 grams salt
- 1.3 grams baking soda
- 2 grams vanilla extract
- 28, 42, or 56 grams butter
- 40, 61 or 82 grams flour

54 cookies were prepared in total!

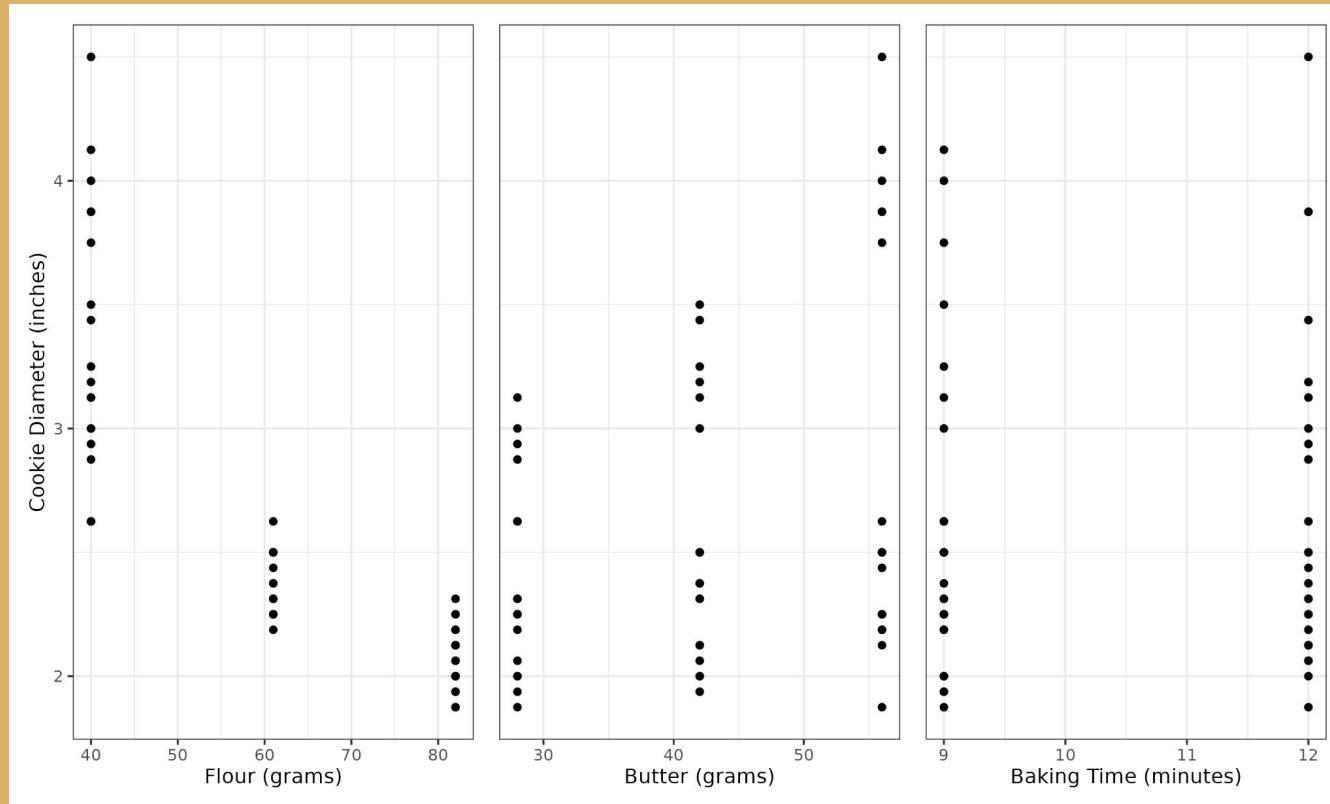
Batch Number	Baking Time (minutes)	Butter (g)	Flour (g)
1	9	28	40
2	9	28	61
3	9	28	82
4	9	42	40
5	9	42	61
6	9	42	82
7	9	56	40
8	9	56	61
9	9	56	82
10	12	28	40
11	12	28	61
12	12	28	82
13	12	42	40
14	12	42	61
15	12	42	82
16	12	56	40
17	12	56	61
18	12	56	82



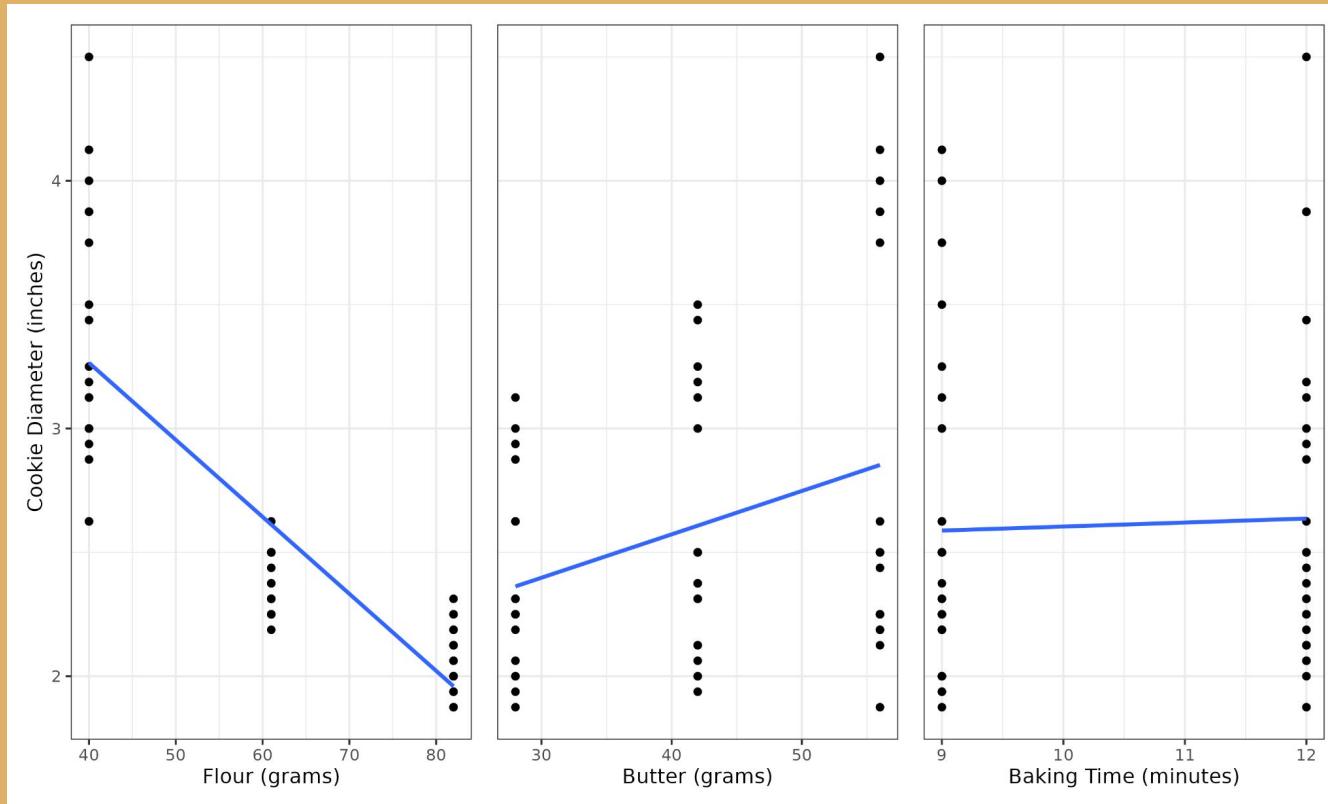
Results



Results: Initial Data Analysis



Results: Initial Data Analysis



Results: Model 1

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \epsilon_i$$

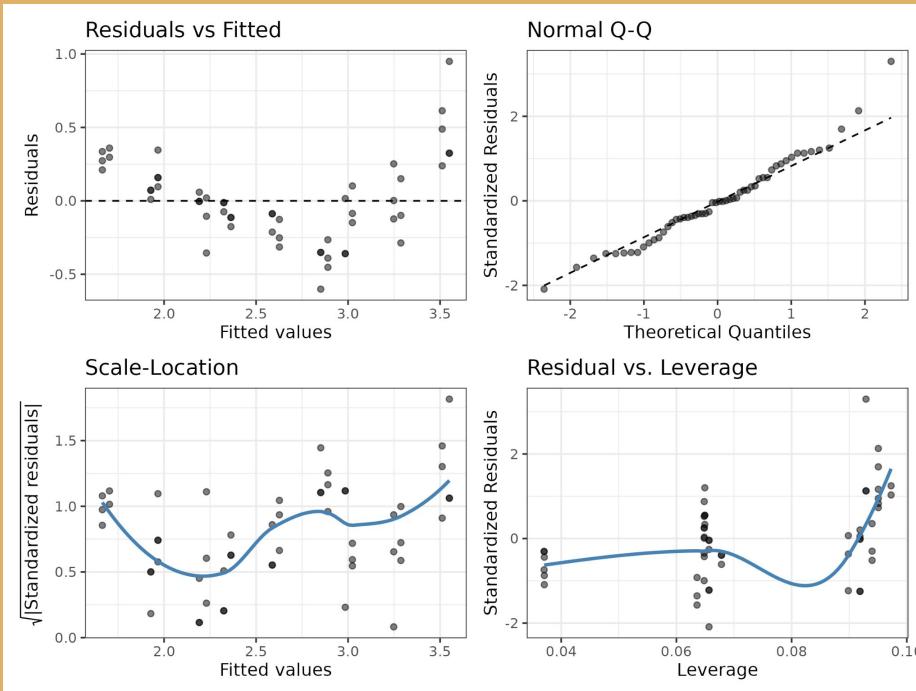


Table 1: Linear Model(s) Predicting Cookie Diameter

	Dependent variable: diameter_in		
	(1)	(2)	(3)
butter_g	0.019 (0.004)		
flour_g	-0.031 (0.002)		
time_in_oven_min	0.013 (0.027)		
Constant	3.598 (0.349)		
Observations	54		
R ²	0.802		
Adjusted R ²	0.790		
Residual Std. Error	0.296 (df = 50)		
F Statistic	67.511*** (df = 3; 50)		

Results: Model 2

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_4 x_{4i} + \beta_5 x_{5i} + \epsilon_i$$

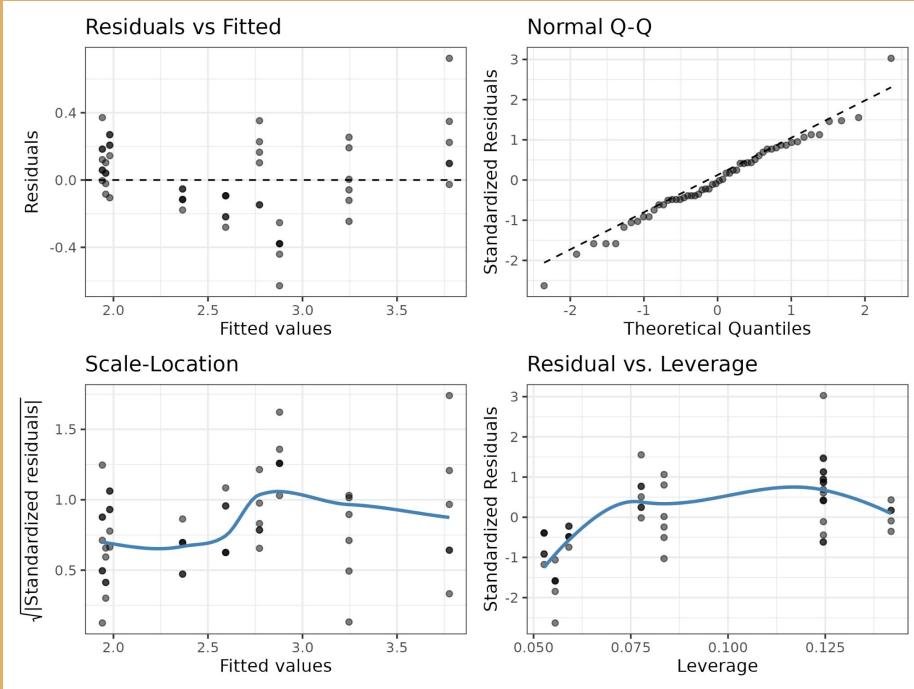


Table 1: Linear Model(s) Predicting Cookie Diameter

	Dependent variable: diameter_in		
	(1)	(2)	(3)
butter_g	0.019 (0.004)	0.057 (0.032)	
flour_g	-0.031 (0.002)	0.004 (0.008)	
time_in_oven_min	0.013 (0.027)		
f_times_b		-0.001 (0.0002)	
butter_sq		0.0001 (0.0004)	
Constant	3.598 (0.349)	1.835 (0.754)	
Observations	54	54	
R ²	0.802	0.864	
Adjusted R ²	0.790	0.853	
Residual Std. Error	0.296 (df = 50)	0.248 (df = 49)	
F Statistic	67.511*** (df = 3; 50)	77.593*** (df = 4; 49)	

Results: Model 3

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_6 x_{6i} + \epsilon_i$$

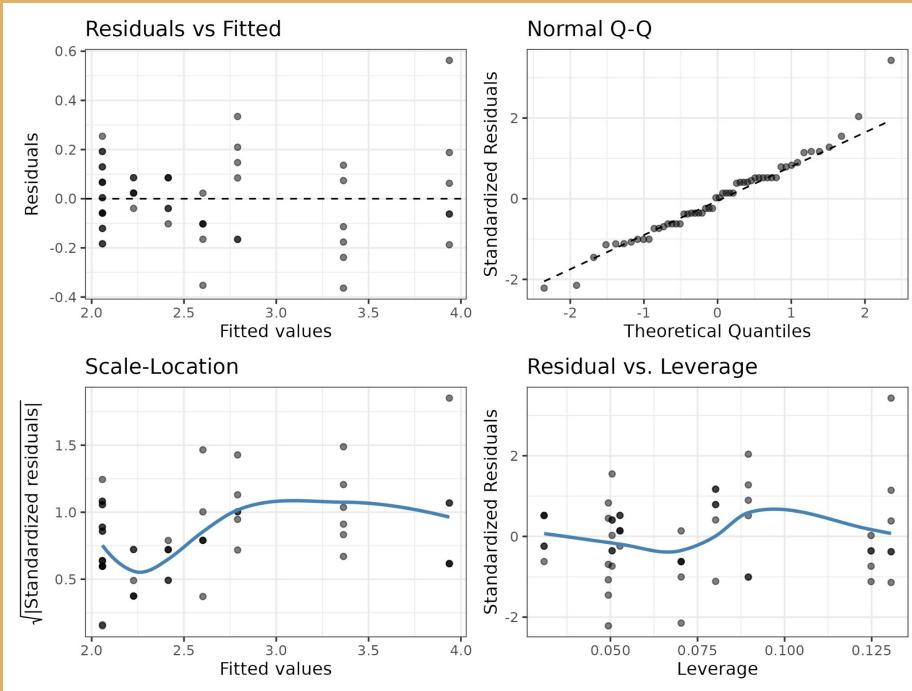


Table 1: Linear Model(s) Predicting Cookie Diameter

	Dependent variable: diameter_in		
	(1)	(2)	(3)
butter_g	0.019 (0.004)	0.057 (0.032)	-0.039 (0.006)
flour_g	-0.031 (0.002)	0.004 (0.008)	0.010 (0.004)
time_in_oven_min	0.013 (0.027)		
f_times_b		-0.001 (0.0002)	
butter_sq		0.0001 (0.0004)	
bf_ratio			3.201 (0.313)
Constant	3.598 (0.349)	1.835 (0.754)	1.247 (0.271)
Observations	54	54	54
R ²	0.802	0.864	0.936
Adjusted R ²	0.790	0.853	0.932
Residual Std. Error	0.296 (df = 50)	0.248 (df = 49)	0.169 (df = 50)
F Statistic	67.511*** (df = 3; 50)	77.593*** (df = 4; 49)	242.364*** (df = 3; 50)

Discussion

- Why were factors such as flour and butter significant, while baking time was not?
 - Unique physical properties of flour and butter
 - More factor levels?
 - Other response variables?
- What were the potential limitations of our experiment?
 - Cost
 - Time
 - Uncontrolled variables



